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Nr. 4. Å. VEDEL TÅNING: ON THE EGGS AND YOUNG STAGES OF THE HALIBUT

KØBENHAVN
C. A. REITZELS FORLAG

BIANCO LUNOS BOGTRYKKERI A/S

1936

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INTRODUCTION

During the spring cruise of the "Dana" in April—May 1934 we were successful in obtaining the eggs of the Halibut between the Faroes and Iceland. These eggs were exhibited at a meeting of the North-Western Area Committee of the International Council on June 6th (see Rapp. et Procès-Verbaux des Réunions. Vol. 89, I. pp. 26, 47) and Mr. G. ROLLEFSEN was able to verify the determination at the meeting, as he had but recently undertaken experiments with artificially hatched Halibut eggs; he had written a paper on the subject ready for printing. From the cruises of the "Dana" in recent years we possess a number of pelagic postlarval stages, as also 7 bottom-stages of the 0-group which have not been described up to the present. With this material as basis it seems appropriate to review here our present knowledge of the early conditions of life of the Halibut in the North Atlantic.

From various quarters I have received valuable information and I wish to tender my best thanks here especially to Professor JOHAN HJORT, Professor E. EHRENBAUM, Professor AD. S. JENSEN, Magister PAUL M. HANSEN and Mr. GUNNAR ROLLEFSEN for their assistance; Mr. ROLLEFSEN has kindly lent me a collection of the eggs used in his hatching experiments for comparison; Professor JENSEN and Mr. PAUL M. HANSEN have lent me some postlarval stages from the "Godthaab"-Expedition. The artist P. WINTHER has drawn the figures to illustrate this paper and Dr. H. M. KYLE is responsible for the translation into English.

It is stated in the literature that eggs and larvæ have been found of *Hippoglossus stenolepis* Schmidt from the North Pacific, a very closely related species to *Hippoglossus hippoglossus* (L.) (Report Intern. Fisheries Comm. Pacific Halibut Fishery, No. 7. Seattle 1930, pp. 24—25; *ibid.* No. 8, 1934, p. 28), but so far as I am aware, no descriptions or details of the discoveries have yet been given and I am thus unable in the following, to make any comparison of the early conditions in the two forms.

A. Eggs of Halibut.

As it had become clear to me, judging from the occurrence of the postlarvæ and references to the occurrence of ripe fish, that the spawning time of the Halibut must lie chiefly in March—May and the spawning places out near the 1000 metre line and deeper, I used the occasion in 1934, when the "Dana" was proceeding early in May from the Faroe Bank to Iceland, to make a search for them. Assuming that the eggs were bathypelagic, our intention was to fish

down through the whole column of water to the bottom, but severe weather at the time prevented this. It was only at two stations that we managed to fish in depths where the eggs might be expected; the stations are noted on the chart Fig. 2 (marked $\triangle$).

Table 1. Records of eggs.

St. 5082. 6/V 1934; 7.30. 61°22' N. 9°53' W. Wind South 6. (N. W. of Faroe Bank) (Depth 1100 m.)		St. 5083. 7/V 1934; 9.30. 62°45' N. 16°01' W. Wind West 5, rising to 7. (S. of Ingolfshöfði) (Depth 1975 m.)	
Metres wire	No. of eggs	Metres wire	No. of eggs
0	0	0	0
50	0	..	..
100	0	..	..
300	0	..	..
..	..	500	0
600	1	..	..
..	..	1000	2
..	..	1500	2
..	..	2000	6

It would thus appear, that most eggs occur at a depth of ca. 700 metres (one-third of wire length out). The list on p. 21 gives details regarding the small number of eggs. A later attempt, off Westre Horn on 18/V (St. 5113, 63°38' N., 14°13' W., Depth 1060—1125 m.), where lengths of 1800 and 2000 metres wire were used, yielded no Halibut eggs, but numerous eggs of *Argentina silus*.

In addition to eggs taken from ripe Halibut and eggs spawned in aquaria we have a notice of their discovery from the coast of Norway, given by Professor D. DAMAS who (according to ROLLEFSEN 1934, p. 20) is said to have found the eggs in November 1905 off Aktivnesset at 400 m. (ca. 62°55' N.) and in March 1906 in Breisunddypet at 300 m. (ca. 62°25' N.); but of these discoveries no further information is available.¹⁾

Previously eggs from mature females have been mentioned or described by, among others, HOLT, M'INTOSH, WILLIAMSON and NORDGÅRD; their diameter is given by HOLT to lie between 3.07 and 3.81 mm., by M'INTOSH between 3.43 and 3.76 mm., by WILLIAMSON between 2.75 and 3.35 mm. and by NORDGÅRD as 3—3.5 mm.; ROLLEFSEN's measurement 3.2 mm. fully agrees with these statements. The free-swimming eggs fished between the Faroes and Iceland also agree; after being preserved in 2 % formaline for 22 months the diameter of most is 3.39—3.57, a single example, however, only 2.94 mm.²⁾ Presumably, to judge from my experience with other fish eggs, they have shrunk in size a little since they were taken, but scarcely more than ca. 0.1—0.2 mm.; thus, HOLT's measurements undoubtedly give very approximately the general size of Halibut eggs. These are smaller than the eggs of the Greenland Halibut, for which AD. S. JENSEN gives 4—4.5 mm. (1935, pp. 6—7). HOLT supposed,

¹⁾ JOHAN HJORT, in his important work on: "Fiskeri og Hvalfangst i det nordlige Norge" 1902, pp. 44—45, has mentioned the Halibut eggs; Prof. HJORT has very kindly informed me, that one may disregard this notice, as the eggs were not described and there has apparently been a mistake; knowledge of the eggs of fishes at that time, the childhood of investigations of the sea, was incomplete.

²⁾ Though the last mentioned egg is quite similar to the others, further studies may show if one of the deep sea fishes in the area probably has eggs of this size and appearance.

that the egg when spawned had a large perivitelline space, like the egg of *Drepanopsetta*, but we now know that this is not the case.

The egg, of ca. 3–3.8 mm. in diameter, has a fairly thick capsule by comparison with other deep-sea eggs; in this it resembles the *Argentina* egg. The egg capsule is smooth and shiny; the egg has but a small perivitelline space and the yolk is clear and transparent, perhaps with a quite faintly yellowish tinge; on close inspection one can detect here and there as a very slight segmentation of the yolk (more distinct on preservation of the egg); there is no oil-globule.

As mentioned, ROLLEFSEN (1934) has hatched out eggs spawned and fertilised in the Tronhjem Aquarium and gives a number of very fine figures of the developmental stages as the

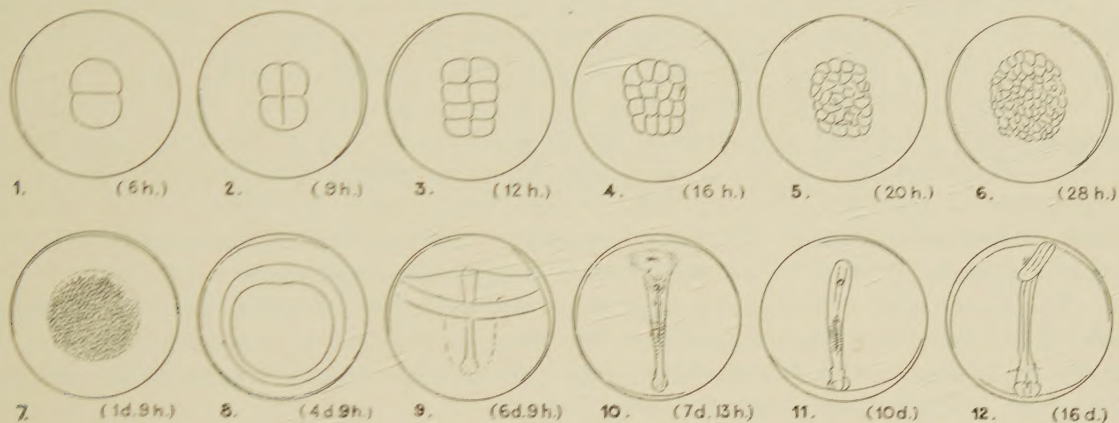


Fig. 1. Sketches of the eggs of the Halibut, from Fig. 1 in ROLLEFSEN 1934. Age of eggs given in hours and days.

result of his important work. In Fig. 1 I give the outline drawings of a series of ROLLEFSEN's figures (Fig. 1, p. 21), in order to show the stages present in the "Dana" material. ROLLEFSEN gives the following information regarding his experiments: the eggs were spawned and fertilised in the aquarium early in March; egg diameter 3.2 mm.; eggs hyaline with small perivitelline space; first segmentation took place after 6 hours; during gastrulation the death-rate was very high; the period of incubation lasted 16 days at 6° C.; the hatched larva (shown in Fig. 3, p. 23 of ROLLEFSEN) was 6.5–7 mm. long, with a huge yolk-sac and entirely lacked pigment; after 6 days the larva measured 8.5 mm.; 10 days old larvæ showed pigment in eye; owing to their dying off the larvæ could not be kept alive until the yolk-sac had been absorbed.

The eggs fished by the "Dana" are for the most part in the stages represented in ROLLEFSEN's Figs. 7–9 (see sketches here in Fig. 1); as these stages are very delicate, the yolk is burst in most; one is slightly younger than ROLLEFSEN's Fig. 10 and a second corresponds to Fig. 10; lastly, one is at a stage between Figs. 11–12 (this specimen was taken in the deepest haul, as we should expect, the eggs probably sinking a little in the water towards the time of hatching).

It has been supposed, that the eggs were not pelagic as they had not been taken anywhere and BIGELOW writes (1925, p. 481): "Eggs spawned naturally have never been seen, but presumably they are not buoyant, and if buoyant they are among the largest of floating fish eggs —". We now know, they are pelagic, floating at great depths, and the reason why they had not previously been known is, that they had not been fished for at the normal spawning places at the right time in the right depth.

There is probably no species of fish, spawning in the area where these eggs were taken, which has eggs of similar appearance to those of the Halibut. There can be no confusion with the *Argentina* eggs (diameter 3—3.5 mm.), which have a large oil-globule; of *Bathylagus benedicti* and *Nansenia groenlandica* we do not yet know the eggs.

B. Pelagic postlarval stages.

1. Additional notes on description of the pelagic stages.

JOHS. SCHMIDT (1904, pp. 5—8, Pl. I, figs. 5—12) gives a precise description of the pelagic stages from 13.5 to 34 mm. long. Further descriptions have not been given by later authors, though PHILIP COX (1924, pp. 411—412) has discussed a couple of stages 20 and 21.5 mm. long from Nova Scotia. Smaller stages than 13.5 mm. have hitherto not been described from specimens taken pelagically. The reason why these stages are not yet known is possibly, that they live bathypelagically out over great depths, where but little fishing has been carried on at the right time of year. ROLLEFSEN (1934), as mentioned above, has discussed the artificially hatched, quite young larvæ of 6.5—7 mm. in length, and has given a figure of this as also a figure of a 6 days old stage of 8.5 mm. from the aquarium experiment.

The more recent material of pelagic stages from the North Atlantic does not contain any smaller stages than the 13.5 mm. specimen described by SCHMIDT, so that I am unable to deal further with these and I shall only refer to the older pelagic stages in regard to the red chromatophores; of these a brief account may be given.

In SCHMIDT's descriptions of the postlarval stages of the Halibut it is practically only the distribution of the melanophores, not of other chromatophores, he refers to, due naturally to the fact, that the descriptions were based on preserved material from which as a rule other chromatophores have disappeared. On p. 6, however, SCHMIDT also notes briefly that red chromatophores were observed in a specimen of $16\frac{1}{4}$ mm. long. As I had the opportunity, whilst working to the south-west of Iceland in 1925, of examining quite fresh material of small postlarvæ, I may here give a copy of my notes on the presence of other chromatophores than the black in a postlarva of 21 mm. in length (St. 2307; 300 metres wire out. See lists p. 22).

In addition to the melanophores the postlarval stages of the Halibut show many, though small, orange-red chromatophores almost everywhere. Few postlarval Teleosteans in boreal-arctic waters have chromatophores of a red colour, usually they are yellow, yellowish-green or brown. The distribution of the erythrophores on the 21 mm. long specimen referred to was as follows (the specimen was still practically symmetrical). Above the brain there are small, scattered erythrophores, here smaller than the smallest of melanophores at the place; they are present not only over the cranial part of the head, but everywhere on the head, though few and small; on the snout and tip of lower jaw, however, they are grouped into slightly more obvious spots. Some are arranged along the cleithrum, also more obvious. On the abdominal wall and gut there are but few scattered erythrophores; on the body itself (including caudal portion) they lie along the myomeral septa, though mediolaterally they are also scattered on the myomeres themselves; most are present on the front part of the body, and here especially on the ventral half. The erythrophores run to some extent along the interspinous rays, most are found ventrally; on the fins themselves most lie between the rays and they extend obviously right out to the margin of the fin, though most lie on the basal part of the fin. Even on

the embryonic fin-membrane behind A and D we find many, very small erythrophores. On the other hand, there are none on the caudal fin except for a small spot ventrally at the base; as is known, the postlarva of the Halibut is characterized by the fact, that melanophores are also lacking on the caudal fin.

It may be added, that the eye in this specimen had a blue silvery sheen, with blue-black iris and black margin (most prominent dorsally).

2. Distribution of the pelagic stages.

Records of the finding of pelagic stages of the Halibut are given by the following authors:

- JOHS. SCHMIDT 1904, pp. 5—8, Pl. I, Figs. 5—12. Faroese and Icelandic waters (see p. 21).
 P. JESPERSEN 1917, pp. 28—30. Faroese and Icelandic waters (see pp. 21—22).
 PHILIP COX 1924, pp. 411—412. Off Nova Scotia (2 postlarvæ, 20 & 21.5 mm.).
 AD. S. JENSEN 1926, pp. 94—96. West Greenland (2 postlarvæ, 14.75 & 21 mm.).
 JOHS. SCHMIDT 1926, pp. 18—19, p. 22. A map reviewing all North Atlantic records up to 1925.
 G. ROLLEFSEN 1934, p. 20. West Norway (3 postlarvæ, no lengths given).

E. EHRENBAUM (1905—09), PRINCE (1916) etc. refer to the above-mentioned work of SCHMIDT from 1904; various works apart from those mentioned have recorded postlarvæ as belonging to the Halibut, but in all cases these have been the postlarvæ of other Pleuronectids.

Since SCHMIDT's review of 1926 a number of pelagic stages have been taken in the waters round the Faroes and Iceland and in the Denmark Strait; the localities are noted in the lists p. 22 and the records are given on the chart Fig. 2, p. 9. These records show, that pelagic stages of the Halibut may be carried by the west-going branch of the Irminger Current far out into the Denmark Strait over towards East Greenland, just in the same way as has been shown to be the case with the young of the Cod, which are borne from Icelandic waters over to East Greenland. The tiny stages, however, have not yet been met with in the west side of the Denmark Strait, where possibly this species does not spawn at all; on the other hand, the postlarvæ of the Greenland Halibut have been found there (see p. 18).

The Chart Fig. 2 indicates also, that the tiny stages (< 20 mm.) were almost all taken outside or quite near to the 1000 metre line, whilst some of the older stages were found somewhat far inside this line, undoubtedly carried there by the current. See also later, i. a. Table 3, p. 8.

As will be seen from the chart, postlarvæ of the Halibut have been taken by the Danish investigations only in the Atlantic waters south-west of the Greenland-Iceland-Faroes-Scotland ridge, thus in an area where forms such as *Molva byrkelange*, *Sebastes marinus*, *Bathylagus benedicti* and other species form a more or less, well-defined community of fishes spawning in boreal Atlantic water outside the continental shelf. The Halibut fry taken in over this ridge belong to the older stages, which have been carried there by the current. None have been taken north or east of the Faroes, on the east or north coasts of Iceland or at East Greenland, that is, none in the cold area.

The postlarval stages¹⁾ and eggs²⁾ recorded by ROLLEFSEN from fjords on the west coast of Norway show, that the Halibut must also spawn there in suitable localities; but no details of the conditions are yet known. The literature also contains a few references to ripe Halibut

¹⁾ Herløvfjord and Jørundfjord off Sæbø (ca. 60°36' N. & ca. 62°12' N.).

²⁾ Aktivneset, Breisunddypet, Buddypet (ca. 62°30' N., ca. 62°25' N. & ca. 62°55' N.).

occurring some distance away from the main spawning region, for example, in the northernmost part of the North Sea; if spawning actually takes place here is not yet known.

It may also happen, as shown by AD. S. JENSEN's records of postlarvæ, that successful spawning may take place at West Greenland, at least in certain years.

Lastly, there is the above record of postlarvæ from the American side of the Atlantic, from Nova Scotia, where a couple of postlarvæ were taken near land, probably carried there by the current.

The following Table shows at what depths the various postlarval stages were obtained; the actual depth would be about one-third of the length of wire indicated.

Table 2. Vertical distribution of pelagic stages of Halibut.

Metres of wire out	13—19 mm.	20—34 mm.	Total
15— 25	4	5	9
50— 80	12	17	29
100— 150	1	7	8
200— 250	..	2	2
300	..	1	1
1000—1500	..	1	1
Total...	17	33	50

It should be noted, however, that we have fished many more times with 15—25 and 50—80 metres wire than in the other depths; it is thus doubtful, whether there are really such greater numbers relatively in the upper layers than somewhat deeper. The reason why so few pelagic stages altogether have been taken is, undoubtedly, that they are uniformly distributed in a very large expanse of water; this reduces the chance of taking them.

If we study now the question, over what depths were the different stages taken, we obtain the clear picture shown by Table 3; this includes also the records of eggs and bottom-stages of the 0-group.

Table 3. Distribution according to depth of locality.

Depths in metres	Eggs	Postlarvæ 13—19 mm.	Postlarvæ 20—34 mm.	Bottom stages
<50	..	..	2: 30—34	7: 47—64
50— 100	..	..	2: 26—28	..
100— 200	..	..	1: 24	..
200— 300	..	..	1: 22	..
400— 600	..	..	2: 26—27	..
700—1000	..	10: 16—19	12: 21—28	..
1000—2550	11	7: 13—19	13: 21—29	..

It will be seen, that the eggs were only taken out over depths greater than 1000 metres, the small postlarvæ < 20 m. only over depths greater than 700 metres, whilst the older postlarvæ are then scattered by the currents and perhaps also wander actively into shallower water (note in particular that the two largest stages were both taken inside the 50 metre line); lastly, the bottom-stages have so far only been taken in shallow water. We may assume, however, that many are also forced to seek the bottom in somewhat deeper water; otherwise we should certainly have found them at an earlier date.

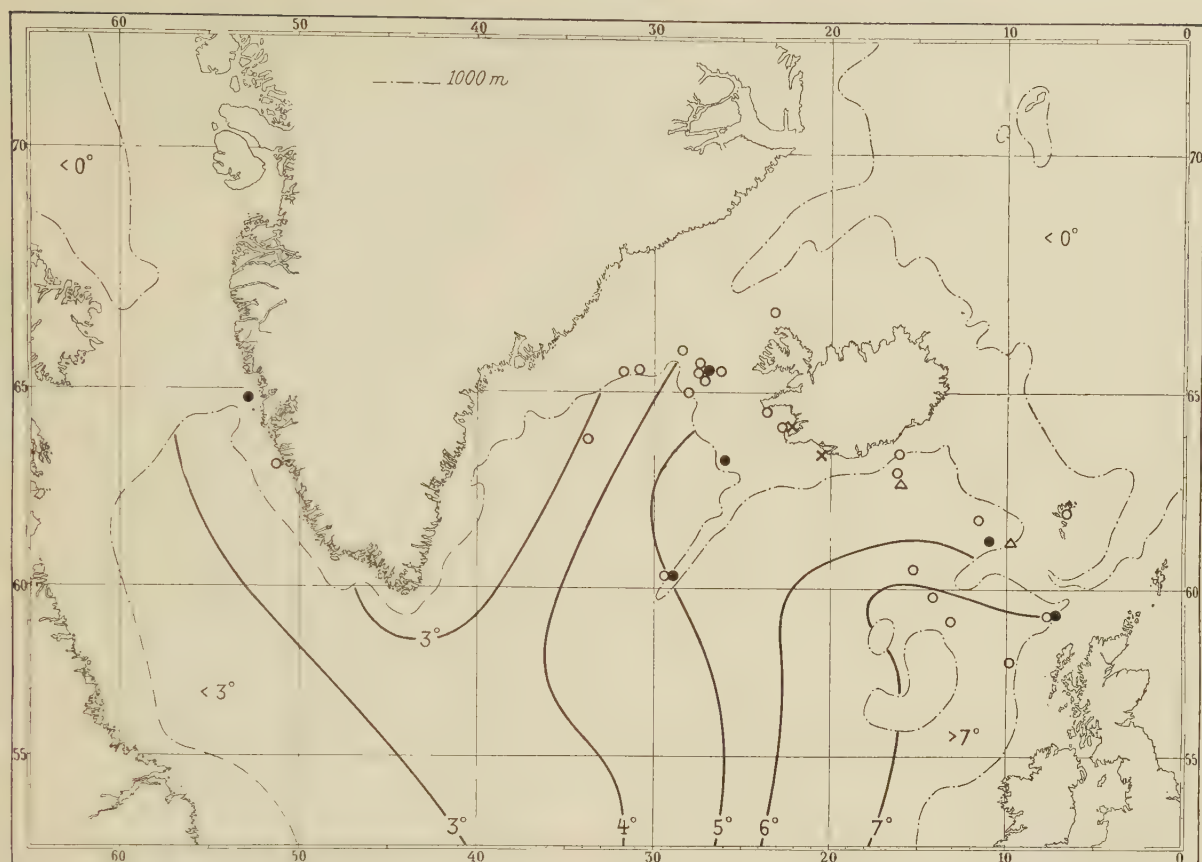


Fig. 2. Distribution of eggs, pelagic postlarval stages, and bottom stages of the 0-group of the Halibut. $\triangle$ eggs, $\bullet$ postlarval stages 13.5–19 mm., $\circ$ postlarval stages 20–34 mm., $\times$ bottom stages of the 0-group 47–64 mm. 1000 metres isotherms from SCHOTT 1926.

C. The smallest bottom-stages of the 0-group.

Hitherto we have not known smaller bottom-stages of the Halibut than the specimens of ca. 8 cm. in length belonging to the I-group. This group, for example, can be taken in Faxø Bay in fairly large numbers in June–July when they have a length of 8–15 cm.; on towards September the largest individuals of the I-group reach up to 23 cm., at the Farøes even to a greater length (JESPERSEN 1917, 1926 and 1936). When the postlarvæ metamorphose and seek the bottom has not hitherto been known; BIGELOW 1925, p. 478, supposes that “the young take to the bottom at a length of 4 to 5 inches”, thus about 10–12 cm. in length.

In Faxø Bay and at South Iceland during recent years hauls with the trawl (fine mesh covering over cod-end) have yielded 7 bottom-stages of the 0-group; their size can be seen from the following, as also date etc. of capture (see also Table 7, p. 15).

Table 4. Records of small bottom-stages of the 0-group.

Faxø Bay, depth 30–37 m.	South Iceland, depth 47 m.
31/VII 1925. 3 sp. 47.0, 47.7, 48.6 mm.	30/VII 1927. 1 sp. 64.1 mm.
27–29/VII 1931. 3 sp. 47.4, 48.2, 51.0 mm.	

All the specimens were obtained in the last days of July; this is undoubtedly very near the earliest period when the 0-group can arrive at depths below 50 metres as bottom-stage. They were taken on hard sandy bottom, where stones and the like might be harmful to the trawl.

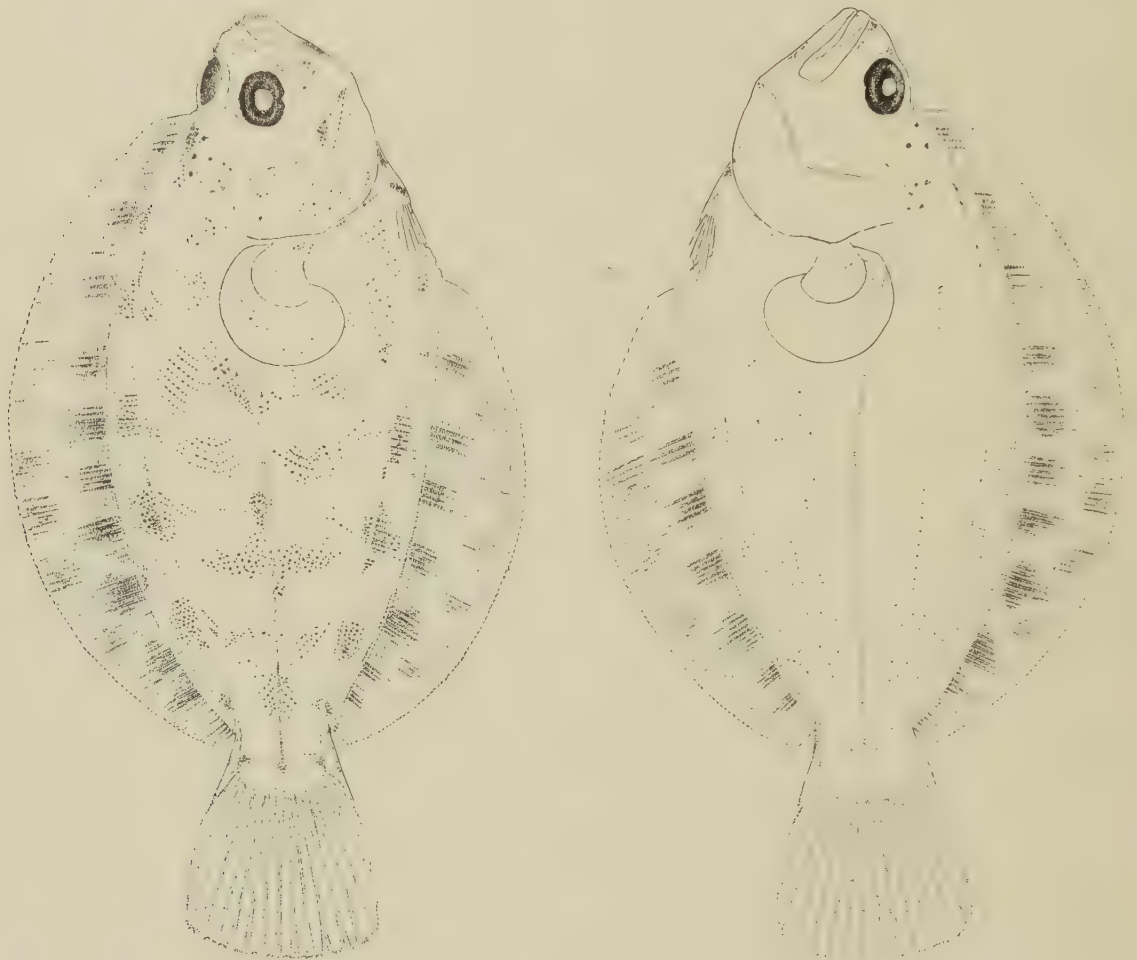


Fig. 3. Postlarval stage 30.1 mm. (W. of Iceland, St. 2176, 1924).
Specimen seen from right and left side.

The largest pelagic postlarva described by SCHMIDT was 34 mm. long, the smallest bottom-stage 47 mm.; between these two lengths therefore takes place the transition from the pelagic to the bottom life, probably at a length of about 35—40 mm. (Cf. Table 7, p. 15). Fig. 4 shows one of the smallest stages (47.4 mm.) seen from both right and left side; for comparison a figure of a pelagic stage of 30.1 mm. is added (Fig. 3).

The available small bottom-stages can be identified with the greatest ease as belonging to the Halibut and not to one of the near or more remote species of flat-fish; the course of the lateral line, number of rays in dorsal and anal etc. agree fully with the specific characters of

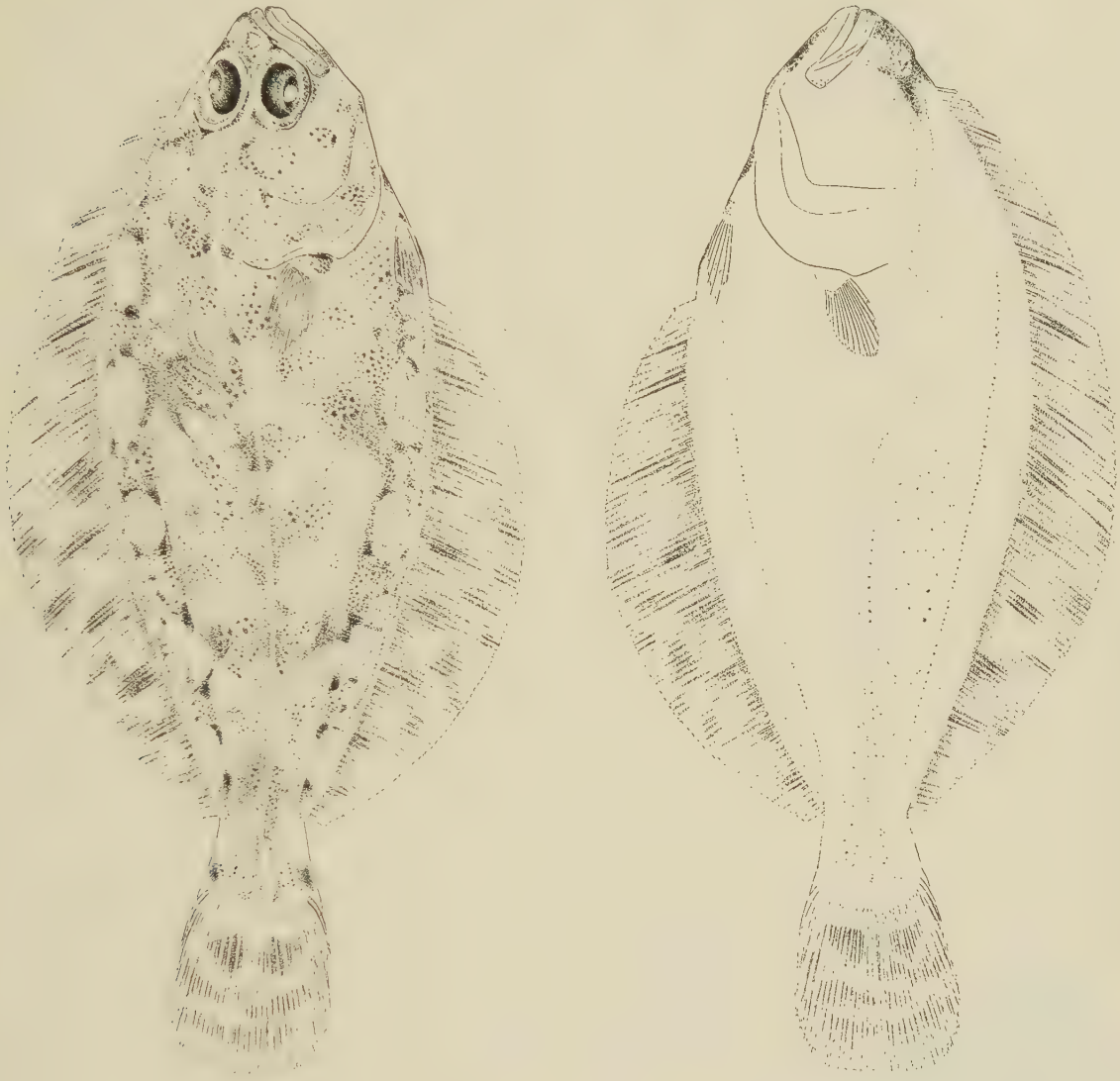


Fig. 4. Bottom stage of the 0-group. 47.4 mm. (Faxé Bay, St. 4243, 1931).
Specimen seen from right and left side.

the adult. Further, the distribution of the pigment preserved corresponds closely, not only with that of the postlarval stages but with that in the I-group of Halibut also.

On capture these small bottom-stages were much more strongly pigmented than the drawing of the specimen preserved in formaline shows. The pigmentation was vivid and strong, almost quite black and chestnut-brown, but unfortunately I had not noticed that this pigment

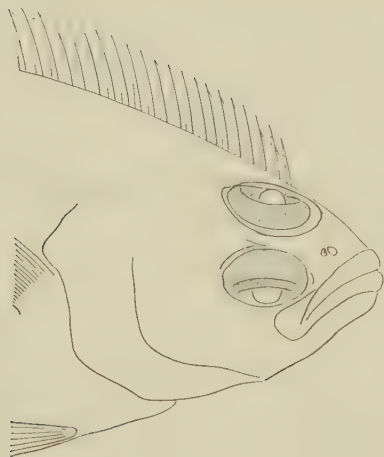


Fig. 5. Outline of the head of Halibut, 112.5 mm. total length (I-gr., Faxe Bay).



Fig. 6. Outline of the head of Halibut, 411 mm. total length (III-group?, Icel.).



Fig. 7. Head of Halibut, 1900 mm. total length (♀, ca. XXII-group, Faxe Bay, $\frac{5}{7}$ 1932).

quickly faded; otherwise a coloured sketch of the newly captured specimens would have been made. In specimens of the I-group the pigment is considerably more resistant.

The pelagic stage of 30.1 mm. shown for comparison with the bottom-stage figured corresponds closely to the 29.5 mm. specimen figured by SCHMIDT 1904 (Pl. I, Fig. 11), though slightly further on in pigmentation; the eye has not yet travelled over the dorsal ridge, the pectoral fin is large and embryonic; rays have just begun to appear along its dorsal margin; the pigment on the body, in contrast to the condition in stages smaller than about 25 mm., has begun to arrange itself in a very characteristic pattern on the right side, a pattern retained and more or less still distinct in specimens of the I-group; several other characters might be emphasized, but comparison with the figures given by SCHMIDT will show the relation of this stage with the still younger.

In the slightly older stages of 34 mm. (SCHMIDT l. c. Fig. 12), where the left eye is on the ridge, the pigment has become denser and more concentrated, especially along the inter-spinous regions; here we find dorsally 6 and ventrally 5 characteristic patches, quite similar to the condition in the youngest bottom-stages; at the base of the caudal fin we now find a couple of distinct pigment spots, also seen again in the young bottom-stage; the pectoral fins still retain their larval character.

The youngest bottom-stage (Figs. 4a and b) shows on the right side both the characteristic pigmentation already mentioned and the other patches of pigment we find in specimens of 30 and 34 mm., quite clearly displayed in all details, and further description is not necessary. On the other hand, the postlarval melanophores on the brain-case, which are characteristic for the species, have now practically disappeared, whilst the caudal fin has now acquired quite a lot of pigment where no pigment was present in the earlier stages (in contrast to *Drepanopsetta*). The larger patches along the bases of the dorsal and anal fins have not changed much since the pelagic stage; in specimens of the I-group they are usually still apparent. On the whole of the right side also we now find an increase of the scattered melanophores (in addition to the pigment of other colours, which has faded on preservation). The left side has still retained certain parts of the weak postlarval pigment, but this is also about to disappear and is nearly quite absent in the I-group; patches of pigment, already distinct at a length of 30 mm., are now more strongly developed round the nostrils, on the lower jaw and at the isthmus; similarly, the caudal fin has now acquired some pigment, whilst the pigment on the dorsal and anal fins has become

fainter and is scarcely noticeable in specimens of the I-group; on the other hand, the pigment on the head still remains distinct in specimens a year old.

The youngest bottom-stage is somewhat different in shape from the oldest pelagic stages; for example, the caudal peduncle and the body have become more slender relatively, which gives the fish on the whole a more slender appearance. The caudal fin, however, is still not indented as in the I-group or still older stages. The eye has now mounted right over to the right side and the pectoral fins have all their rays formed, their shape being almost as in the older individuals; the right pectoral is likewise longer than the left. The lateral line is distinctly marked and on the whole it is difficult to note any great differences between this stage and specimens of the I-group, that is to say, the transformation to a flat-fish has taken place during growth from 34 to 47 mm.

The following Table (5) gives a number of measurements of a series of stages from 47 mm. up to fully 400 mm., to show how the proportions alter with growth (all measurements in % of standard length; from material preserved in formaline). The measurements of a pelagic stage of 30.1 mm. are also given. As will be seen, the form changes are on the whole not very drastic, if we exclude the change in the relative size of the eye. It will be noted, however, that the head becomes slightly smaller and the preanal length is also reduced etc.

Table 5. Measurements of Halibut from Iceland waters. (Percentages of Standard length).

Total length mm.	Standard length mm.	Depth of body	Head	Eye		Inter-orbital width	Preanal length	Caudal peduncle	Pectoral		Notes
				dex.	sin.				dex.	sin.	
30.1	24.9	41.0	29.3	7.7	7.6	4.5	39.4	8.8	15.3	15.3	0-gr. pelagic stage
47.0	39.8	35.7	30.4	7.5	7.8	2.3	38.2	10.6	10.8	8.0	0-gr. bottom stage
47.4	40.0	37.0	29.5	7.0	6.8	2.3	35.0	12.5	?	?	—
47.7	40.1	36.2	29.7	6.7	7.0	2.2	36.4	10.2	11.5	8.7	—
51.0	42.7	35.4	30.4	6.1	6.8	2.3	38.6	9.8	11.7	9.4	—
96.5	83.2	33.7	29.3	7.7	7.7	1.6	38.6	11.7	11.5	8.5	I-group
111.5	95.5	36.1	29.6	7.5	7.4	1.7	39.3	9.8	13.3	9.8	—
112.5	96.6	34.2	28.8	7.1	7.0	1.7	35.0	11.7	12.2	9.3	—
123	105.4	34.2	27.8	6.8	6.6	1.9	35.9	8.0	11.9	9.0	—
136	114.7	34.5	28.8	6.5	6.5	1.7	34.2	12.5	13.5	9.6	—
142	120.8	35.3	28.5	6.4	6.3	1.7	38.9	11.0	12.1	10.0	—
240	209.0	34.7	27.0	5.4	5.7	1.6	31.4	11.7	13.2	9.3	II-group
262	224.0	34.7	25.9	5.2	5.4	1.9	32.2	11.8	12.8	9.7	—
279	242.0	35.1	27.1	5.7	5.6	1.7	32.9	12.4	13.5	9.5	—
331	285.0	35.2	25.8	4.8	4.8	1.9	33.1	11.3	12.7	9.9	—
411	353.0	38.2	26.0	4.4	4.7	2.1	33.3	13.4	12.5	10.4	III-group?

A remarkable thing is, however, that the eye of the Halibut during growth does not follow the growth of the adjacent parts of the head or the growth of the body as a whole; specially obvious is therefore the apparent increase in width of the interorbital space, to illustrate which I have given drawings of the heads of a couple of stages of 112.5 mm. and 411 mm., as also a photograph of this region in a specimen of 190 cm. (Figs. 5—7); these may be compared with the figure of the bottom-stage of the 0-group (Fig. 4a). Cf. also NORMAN 1934 pp. 33 and 292.

The following proportions between longest diameter of eye and interorbital width may be of interest in this connection.

Table 6. Proportion between eye and interorbital width.

	Pelagic stage	0-group, bottom-stage						I-group						II-group and older					
Total length mm.	30.1	47.0	47.4	47.7	51.0	64.1	96.5	111.5	112.5	123	136	142	240	262	279	331	411	1900	
Eye/Interorb. . .	1.7	3.3	3.1	3.0	2.6	3.3	4.9	4.5	4.3	3.6	3.8	3.9	3.3	2.8	3.4	2.6	2.1	0.6	

It is very obvious from the series of figures, that the interorbital width is least in proportion to diameter of eye in the I-group, thereafter increasing with the growth, that is to say, the eye does not grow with the rest. On the other hand, it will be seen from Table 5, that the interorbital width, after the migration of the eye has been quite completed in specimens of the 0-group, does not change much in relation to the standard length in the I-group and older stages up to a length of ca. 40 cm. (I have not had the opportunity of examining this character in larger specimens).

D. Spawning season.

Consideration of the available data indicates, that the spawning of this species in the north-eastern area of the Atlantic takes place chiefly in the months of March—April—May, with April as the principal period, even if there are some indications that spawning may also occur earlier and later.

The pelagic eggs found 6—7/V in probably the chief spawning area in the Northern Atlantic are at developmental stages which, judging from ROLLEFSEN's hatching experiments, we may conclude to have an age of between 2 and 15 days; thus spawned late in April or very early in May. The available material of fry also indicates, that the period mentioned is the principal spawning season (see Table 7).

Excluding some older statements based probably on erroneous observations (e. g. CUNNINGHAM's statement that the species spawns at Iceland in autumn), I may just mention here the references to the matter in the literature, so far as known to me.

Eggs: DAMAS (cf. ROLLEFSEN 1934, p. 20) gives March and November for Norway; the latter month (if the determination is correct) falls well outside all other statements regarding the spawning time of the species. 6.—7. May: see this paper p. 4.

Postlarval stages: Norway: March, April—June (ROLLEFSEN).

Northern Atlantic: May—July (present material from "Thor", "Dana" etc.; see summary tables, pp. 21—22; SCHMIDT, JESPERSEN).

Spawning in aquaria: March—April (NORDGÅRD¹), ROLLEFSEN).

Observation of ripe females landed by fishermen: Between 25th January and June: R. COUCH: April; MALM: 26. April; BROOK: March—June; M'INTOSH & MASTERMAN: Chiefly towards the end of April and beginning of May (5/5); similarly EHRENBAUM, KYLE etc.; WILLIAMSON: 25. January—1. May; FULTON: March—June; HOLT i. a. 30. April and beginning of May; SÆMUNDSSON: April.

Spent females: later half of March (SW. Iceland; SÆMUNDSSON); April—June (FULTON 1893); 26. May—19. July ("Thor" 1903—1908).

¹) NORDGÅRD (1927) states that spawning takes place at night in aquaria.

Table 7. Review of all material of pelagic stages and 0-group bottom stages.

mm.	Pelagic stages			Bottom stages
	22.—31. May	June	1.—18. July	27. July—31. August
64	..	..	..	1
..	..	..	..	..
..	..	..	..	..
51	..	..	..	1
50	..	..	..	..
49	..	..	..	..
48	..	..	..	2
47	..	..	..	3
..	..	..	..	..
..	..	..	..	..
34	..	..	1	..
33	..	..	..	..
32	..	..	..	..
31	..	..	..	..
30	..	..	1	..
29	1	1	2	..
28	1	..	2	..
27	..	2	1	..
26	2	2	2	..
25	..	1	..	..
24	1	1	1	..
23	1	1	..	..
22	1	5	..	..
21	2	..	..	..
20	1	..	..	..
19	2	4	..	..
18	1	1	..	..
17	1	..	..	..
16	1	2	..	..
15	2	..	..	..
14	2	..	..	..
13	1	..	..	..
Total..	20	20	10	7
Average length ...	19.95	22.15	28.10	50.29

Even if the observations of ripe females are undoubtedly of value, one has to remember that the majority have certainly been taken outside the localities where the species normally spawns, and thus possibly do not indicate correctly the period of principal spawning on the most frequented spawning places.

Excluding the above November record for Norway (DAMAS) we see, that most of the statements cited agree in placing the spawning time in the period from late January to early in

May, though probably there is but little spawning before March. Some spawning may probably also takes place later in the year (cf. also JENSEN l. c. p. 6 on the Greenland Halibut).

Whether the spawning season off the east coast of America agrees with that in the north-eastern waters of the Atlantic cannot be determined from the little material available. BIGELOW (1925) gives the spawning time (from GOODE 1884) as April on to early September; the postlarvæ from Nova Scotia were taken between 3rd and 6th June (COX 1924). From Greenland waters we have only two postlarvæ from June—July (AD. S. JENSEN 1925).

E. Spawning area and hydrographical conditions there.

We are not yet able to chart the spawning areas of the Halibut in the North Atlantic on the basis of the available material; but it helps to indicate the lines for future work in this field. As already noted and clearly shown by the chart Fig. 2 p. 9 the spawning areas must lie about the 1000 m. line and beyond, south-west of the ridge from North Scotland over the Faroes and Iceland to the eastern end of the Iceland-Greenland ridge; to what depth the spawning Halibut may go down, we have as yet no material to determine. It is evident, however, from the discovery of postlarvæ on the south-west point of Reykjanes ridge, that they can travel a long distance from the coastal areas. The spawning places for this species thus lie outside the areas where the young grow up.

The very few records from West Norway, West Greenland and Nova Scotia do not permit of any precise conclusions regarding the conditions there. So far as Norway is concerned, the discoveries inside the fjords point to special conditions; possibly it is a comparable phenomenon to what has been observed in certain other species of fish, which normally seem to have their spawning place in Atlantic water west of the British Isles and south-west of the Scotland-Iceland ridge (e. g. *Lophius*).

The hydrographical conditions in the main spawning region, as shown on the chart Fig. 2, seem specially to indicate, that the Halibut seeks out to the warm Atlantic water in order to lay its eggs.¹⁾ At a depth of 1000 metres in this area²⁾ we find a temperature between ca. 4° and ca. 7½° C., and a salinity of about 35 ‰. But if the Halibut, as various records indicate, also goes out still deeper to spawn, the temperature will sink to about 3° C. and it is evident, that temperatures of this range could also be found at other places by the species. Possibly a temperature of 5°—7°, perhaps at the same time a salinity of 35 ‰, is necessary at a certain stage of the development of the gonads, though the fish may well be able to spawn later at a somewhat lower temperature. That the depth is not an absolute condition for the spawning, is evident from the fact, that specimens may clearly in a natural manner succeed in spawning in aquaria (NORDGÅRD, ROLLEFSEN); this spawning in aquaria would also indicate, that it is not necessary for the maturing fish to travel any certain distance before it reaches the spawning stage.

In the table below I give a summary of the temperature and salinity records at the two stations where eggs were taken; × indicates the approximate depth at which the eggs were fished.

¹⁾ I assume here, that the Halibut remains at the bottom while spawning, even if we do not know this for certain, as the Halibut has often been observed pelagically in pursuit of its food. ²⁾ The special conditions off W. Greenland are not considered here.

Table 8. Temperature and Salinity at stations where eggs were recorded.

61°24' N. 9°51' W. (St. 5082.) 6/5 1934. Depth 1125 m.			62°45' N. 16°01' W. (St. 5083.) 7/5 1934. Depth 1925 m.		
m.	t°	S ‰	m.	t°	S ‰
0.....	8.57	35.34	0.....	8.77	35.28
10.....	.44	.34	10.....	.74	.26
25.....	.44	.34	25.....	.73	.26
50.....	.44	.34	50.....	.73	.28
75.....	.40	.32	75.....	.71	.30
100.....	.41	.32	100.....	.79	.28
200.....	.40	.32×	200.....	.56	.26
300.....	.40	.34	300.....	.53	.26
400.....	.37	.32	400.....	.49	.28×
500.....	.34	.32	500.....	.07	.26×
600.....	.33	.32	600.....	7.73	.21
800.....	7.72	.23	800.....	6.36	.12×
1000.....	6.18	.14	1000.....	4.98	34.99
			1200.....	.14	.99
			1500.....	3.50	.90
			1700.....	.36	.97
			1900.....	2.68	.99

F. On the occurrence of postlarval stages of the Greenland Halibut, *Reinhardtius hippoglossoides* (Walb.) in the Denmark Strait.

In a recent paper¹⁾ Professor AD. S. JENSEN gives an exhaustive account of the development and occurrence of this species at West Greenland; throughout the years the "Dana" has taken some few specimens during investigations in the Denmark Strait and I may discuss this material briefly here.

The chart Fig. 8 shows the localities where the 30 specimens were taken; at the same time the negative stations within the area denoted by the chart are also indicated. Details of capture etc. are given in the lists p. 22. It should be remarked here further, that we have never taken the pelagic fry of the Greenland Halibut to the north or east of Iceland; this is peculiar, as we have now and then during the summer obtained ripe specimens in the deep water north and northeast of Iceland, where the species is fairly abundant (see SÆMUNDSSON 1908, 1926 etc.).

It appears, that the fry of the Greenland Halibut are only taken on the west side of the Denmark Strait, not in the warmer, east side (cf. charts Fig. 2 and Fig. 8). The fry of this species and of Halibut may come together in the middle of the Strait, both having been taken at the same station and even at the same depth (St. 4235, 50 metres of wire out, see lists p. 23). We may conclude, that the fry of the Halibut are carried here from the eastern side of the Strait, those of the Greenland Halibut presumably from the north-western part of the Strait up towards the Iceland-Greenland ridge. Where exactly the spawning places

¹⁾ AD. S. JENSEN: The Greenland Halibut. Danske Vid. Selsk. Skr., Nat. Afd. 9. R. VI, 4, 1935.

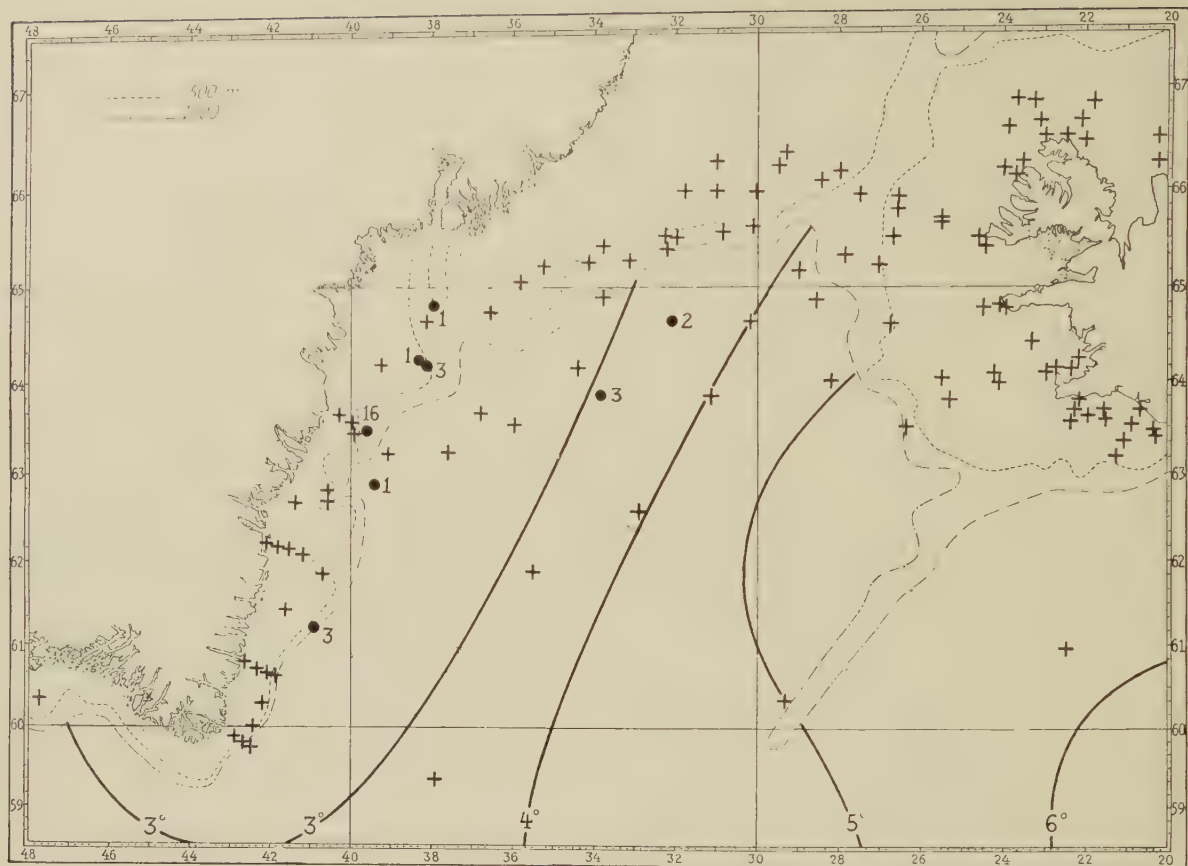


Fig. 8. Distribution of pelagic fry of the Greenland Halibut (*Reinhardtius hippoglossoides* (Walb.)) in the Denmark Strait. 1000 Metres isotherms from SCHOTT 1926. • postlarvæ present, + not present.

of the Greenland Halibut lie, is not known as we have only specimens of 22 mm. in length and upwards; the smallest specimen, however, was taken at the station just mentioned (4235) in the middle of the Strait over a depth of 2550 metres. The depth over which postlarvæ have been taken varies between 300 and 2550 metres. We may possibly assume, by comparison with the conditions shown by AD. S. JENSEN to occur in the Davis Strait, that the mature individuals from East Greenland migrate out into the west side of the Strait whilst others from North and East Iceland likewise seek out into the Strait (perhaps towards the north-west), in order to spawn in great depths on the west and north-west side of the Strait, where they meet with Atlantic water with a temperature of 3° – 4° at a depth of about 1000 metres, just as in the Davis Strait, whilst the east side of the Strait in this depth has still higher temperatures, 4° – 5° or more. The temperature in the water-layers where the fry were taken in the Denmark Strait, lie between ca. 4° and 9° (S. ‰ ca. 33.50–35.15), usually in mixed water on the west side of the Strait. The postlarvæ were taken especially in about 5–35 metres below the surface.

The fry apparently seek into the East Greenland fjords also as they gradually become larger, some having been taken in Tasiusarsik Fjord and Nanusek Fjord (see AD. S. JENSEN 1935, p. 27, footnote).

Table 9. Size of fry of Greenland Halibut, Denmark Strait, 11.—25. July 1925—32.

Length mm.	22	23	24	25	26	27	28	29	30	31	32	33	34	35
No. of spec.	1	..	..	..	3	..	..	2	..	..	..	..	1	..
Length mm.	36	37	38	39	40	41	42	43	44	45	46	47	48	
No. of spec.	3	2	3	1	1	1	3	..	4	2	..	1	2	

The size of the postlarvæ fished in Denmark Strait will be seen from Table 9; the average is 38.1 mm. (range 22—48) and they were all taken in the period 11.—25. July. In 1933 numerous pelagic stations were investigated by the "Dana" from 8.—17. August in the area, where the postlarvæ usually appear in July, but none were taken; presumably therefore the majority of the postlarvæ have changed over to the first bottom-stage at this period of the summer or have drifted out of the area.

The growth of the larvæ is fairly rapid; at West Greenland the average length in June is ca. 20.5 mm., in the first third of July ca. 25.1 mm., in the second third ca. 32 mm. As the average length of the Denmark Strait larvæ is ca. 38 mm. in second third of July, the growth seems here somewhat more rapid, or the spawning time may especially fall a little earlier in the year than in the Davis Strait.

Resumé.

1. Eggs of the Halibut were obtained pelagically for the first time between the Faroes and Iceland at a depth of about 200—700 metres; the depth at the place was about 1100—2000 metres, from which we may conclude that the Halibut migrate out at any rate to these depths in order to spawn.
2. The dimensions of the eggs are ca. 3- 3.8 mm. in diameter; they are transparent with very small perivitelline space and without oil globule.
3. A summary is given of all the pelagic postlarvæ taken in the North Atlantic together with various observations concerning the material.
4. The smallest bottom-stages of the 0-group are described for the first time and various features concerning these rare stages are noted in detail.
5. Various features in the metamorphosis and changes during the further growth are described.
6. On the basis of our present knowledge the spawning period in the Northern Atlantic is considered to fall specially in the months March—April—May with April as the principal period.
7. The hydrographical conditions in the spawning area and conditions connected therewith are briefly discussed.
8. The occurrence of pelagic postlarvæ of the Greenland Halibut in the Denmark Strait is referred to.

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- b) Fiskeriundersøgelser ved Island og Færøerne i Sommeren 1903. Skrifter udg. af Komm. f. Havunders. Nr. 1. København 1904.
- Administrative Report for 1925. Rep. North-Western Area Committee. Rapp. et Procès-Verbaux XXXIX, pp. 18—19, 22 (fig. 4). Copenhagen 1926.
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List of Material.

Records of eggs of the Halibut, *Hippoglossus hippoglossus* (L.)

St.	Date	Hour	Position N. W.	Depth in metres	Gear	Wire out metres	Duration of haul in min.	No. of eggs	Diameter of egg	Notes
Da 5082	6/5 34	7 ³⁰	61°22' 9°53'	1100	S 200	600	60	1	3.47	slightly younger than Fig. 1, 10.
Da 5083	7/5 34	9 ³⁰	62°45' 16°01'	1975	S 200	1000	60	2	3.57	cf. Fig. 1, 7—9.
									?	defect.
"	"	"	"	"	"	1500	"	2	3.39	cf. Fig. 1, 7—9.
									3.39	"
"	"	"	"	"	"	2000	"	6	2.94 ¹⁾	cf. Fig. 1, 7—8 (younger?).
									3.39	cf. Fig. 1, 10
									3.41	" 11—12
									3.48	" 7
									3.49	" 7—8
									3.51	" 7—8
										(younger?)

¹⁾ See note p. 4.Records of pelagic stages and young bottom stages of the 0-group of the Halibut, *Hippoglossus hippoglossus* (L.), from the North Atlantic 1904—1934.

St.	Date	Hour	Position N. W.	Depth in metres	Gear	Wire out metres	Duration of haul in min.	No. of spec.	Length in mm.s	Notes
1904										
T 100	22/5	—	61°21' 10°59'	>1000	Y 200	15	30	1	13.5	Sch. 1904, fig. 5
T 113	24/5	—	63°31' 16°06'	116	"	15	20	1	24.5	
T 151	19/6	—	65°25' 27°30'	c. 750	"	15	15	1	29.5	Sch. 1904, fig. 11
"	"	—	"	"	"	70	"	2	22	
									24.5	Sch. 1904, fig. 9
T 152	19/6	—	65°00' 28°10'	1240	"	1000	30	1	25	
"	"	—	"	"	"	200	"	1	22	Sch. 1904, fig. 8
T 153	20/6	—	65°20' 27°12'.5	740—768	"	100	30	1	27	Sch. 1904, fig. 10
T 154	20-21/6	—	65°27' 27°10'	700—765	"	50	240	1	23	
"	"	—	"	"	"	15	60	1	16.5	Sch. 1904, fig. 6
"	"	—	"	"	"	80	60	2	19.5, 22	
"	"	—	"	"	"	75	180	5	16.25	
									18	Sch. 1904, fig. 7
									19	
									19.25	
									19.5	
T 155	21/6	18 ⁴⁵	65°28' 26°20'	223	"	15	30	1	22	
T 173	7/7	—	64°07' 22°39'	44	"	50	20	1	34	Sch. 1904, fig. 12
1905										
T 58	26/5	21 ¹⁰	63°07' 16°12'	1475	"	65	150	2	19.5, 29	
T 60	28/5	6 ⁴⁵	61°50' 11°38'	1100	"	25	30	1	26	
"	"	7 ²⁰	"	"	"	65	150	2	20, 21	
T 64	30/5	17 ⁵⁰	59°17' 7°29'	895	"	65	60	2	22, 28.8	
"	"	19 ⁰⁰	"	"	"	25	30	2	16, c. 18	
T 72	9/6	2 ²⁰	57°52' 9°53'	1470	"	200	120	1	27	

St.	Date	Hour	Position N. W.		Depth in metres	Gear	Wire out metres	Duration of haul in min.	No. of spec.	Length in mm.s	Notes
1908											
T 22	31/5	20 ⁵⁰	59°10'	13°13'	>1655	Y 200	65	30	1	26	
T 23	1/6	5 ³⁰	59°43'	14°07'	>1500	"	65	30	1	22.9	
T 24	1/6	15 ¹⁵	60°31'	15°22'	>1500	"	100	30	1	26.5	
1924											
Da 2161	2/7	18 ⁴⁵	66°41'	23°09'	78	S 200	65	15	1	28	
Da 2176	15/7	9 ⁵⁰	64°44'	23°41'	<50	"	15	15	1	30.1 ¹⁾	
1925											
Da 2307	30/5	22 ⁴⁵	60°20'	29°21'	1000	S 200	100	60	2	19, 23.5	
"	31/5	0 ¹⁵	"	"	"	"	300	60	1	21	
Da 2443	31/7	13 ²⁰	64°08'	22°23'	30—37	O	250	60	3	47.0, 47.7, 48.6	Bottom stages
1927											
Da 3156	30/7	2 ⁰⁰	63°34'	20°26'	47	O	250	60	1	64.1	Bottom stage
1928											
G 1	24/5	14 ²⁵	63°19'	26°50'	1130	S 200	50	30	5	14.2, 14.5, 15.0, 15.0, 17.6	
1931											
Da 4223	16/7	7 ⁰⁰	65°33'	30°50'	1240	S 200	65	15	1	26	
Da 4235	19/7	22 ³⁰	63°51'	33°51'	2550	"	50	60	2	29, 29	
Da 4243	27-29/7	—	64°08'	22°23'	34—41	O	300	—	3	47.4 ²⁾ 48.2, 51.0	Bottom stages
1932											
Da 4393	22/6	12 ¹⁰	62°04'.5	6°46'	75	S 200	65	15	1	26	
1934											
H 3	8/7	14 ⁴⁵	65°55'	28°28'	c. 500	S 200	115	15	1	27	
H 8	9/7	3 ⁰⁵	65°26'	31°40'	c. 1000	"	115	15	2	24, 28	
H 10	7/7	20 ⁴⁰	65°38'	27°32'	c. 600	"	115	15	1	26	

¹⁾ Fig. 3a and b, p. 10. ²⁾ Fig. 4a and b, p. 11.

Records of pelagic postlarval stages of the Greenland Halibut, *Reinhardtius hippoglossoides* (Walb.), from the Denmark Strait 1931—33.

St.	Date	Hour	Position N. W.		Depth in metres	Gear	Wire out metres	Duration of haul in min.	No. of spec.	Length in mm.s	Notes
1925											
Da 2436	25/7	18 ²⁰	61°13'	40°57'	1780	S 200	50	60	1	40	
"	"	"	"	"	"	S 200	100	"	2	44, 47	
1931											
Da 4228	17/7	13 ⁴⁰	64°49'	37°59'	625	S 200	65	15	1	48	
Da 4229	17/7	21 ¹⁰	64°12'	38°12'	300	S 200	65	15	3	34, 38, 42	
Da 4230	18/7	6 ⁰⁵	63°27'	39°38'	525	S 200	250	15	1	29	
"	"	"	"	"	"	S 200	65	"	14	2/36, 2/37, 2/38, 1/39, 1/41, 2/42, 2/44, 2/45	
"	"	"	"	"	"	S 200	15	"	1	44	

St.	Date	Hour	Position N. W.		Depth in metres	Gear	Wire out metres	Duration of haul in min.	No. of spec.	Length in mm.s	Notes
Da 4232	18/7	20 ⁰⁵	62°53'	39°24'	1925	S 200	65	15	1	48	
Da 4235	19/7	20 ⁰⁵	63°51'	33°51'	2550	S 200	65	15	1	26	
"	"	22 ³⁰	"	"	"	S 200	100	60	1	26	
"	"	"	"	"	"	S 200	50	"	1	22	
1932											
Da 4438	11/7	4 ⁰⁰	64°13'	38°15'	450—470	S 200	65	15	1	36	
Da 4446	14/7	0 ³⁰	64°38'	32°06'	1500?	S 200	65	15	1	26	
"	"	"	"	"	"	"	15	"	1	29	

Y 200 = Petersen young fish trawl, 200 cm. in diam. at opening.

S 200 = Stramin-net, open, conical, 200 cm. in diam. at opening.

O = Otter-trawl, head-rope 15.25 m. (50 feet); fine mesh covering.

T = R/S "Thor"

H = H.M.S. "Hvidbjørnen".

Da = R/S "Dana"

G = S/S "Godthaab"

Dansk Resumé.

1. Helleflynderens Æg er for første Gang mellem Færøerne og Island fisket pelagisk i en Dybde omkring 200—700 Meter; Dybden paa Stedet var ca. 1100—2000 Meter, hvoraf sluttet, at Helleflynderen i hvert Fald vandrer ud til disse Dybder for at gyde.
2. Æggenes Størrelse er ca. 3—3.8 i Diameter, de er klare med meget lille perivitellint Rum og uden Oliedraabe.
3. En Oversigt gives over alle pelagiske postlarvale Stadier, der er taget i det nordlige Atlanterhav, og forskellige Iagttagelser vedrørende dette Materiale gives.
4. De mindste Bundstadier af 0-Gruppen beskrives for første Gang, og Forhold vedrørende disse sjældne Stadier omtales nærmere.
5. Forskellige Forhold vedrørende Forvandlingen og Ændringer under den videre Vækst omtales.
6. Paa Grundlag af vor nuværende Viden afgrænses Gydetiden i det nordlige Atlanterhav til særlig at falde i Tiden Marts—April—Maj med April som Hovedperioden.
7. De hydrografiske Forhold i Gydeomraadet og Forhold hørende herhen omtales kort.
8. Forekomst af pelagiske Postlarver af Hellefisk i Danmarksstrædet omtales.

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